

THE INSTITUTE FOR ADVANCED STUDY

Founded by Mr. Louis Bamberger and Mrs. Felix Fuld

PRINCETON, NEW JERSEY

May 17, 1943

Dear Lieutenant Brunauer:

I have your kind letter of May 13 and have discussed with Dr. Aydelotte, Director of the Institute for Advanced Study, the matter of my cooperation with the Research and Development Division of the Navy. Dr. Aydelotte approves heartily of my participating in your research operations. He and I both feel that the individual contract would be the most suitable, and I agree fully with the arrangements outlined in the enclosed letter from Dr. Aydelotte.

I very much enjoyed your visit and look forward with great satisfaction to this association with you in research on Navy problems. I shall expect to receive from you in due course the contract and information about the work which you wish me to undertake, and I hope that I shall be able to make some useful contribution.

In this connection, I should like to raise one question: Would it in any way interfere with my usefulness to the Navy if I should spend a part of the summer in a cottage at Lake Saranac? I do not know whether it will be possible for me to take a holiday away from Princeton in any case, and certainly if my usefulness to the Navy would be increased by remaining in Princeton I should be most happy to do so. If, however, it would be equally convenient for you, I think I could probably work to better advantage in the more agreeable climate of Lake Saranac during the hot months of the summer.

Yours very sincerely,

A. Einstein.

Lieutenant Stephen Brunauer
Bureau of Ordnance
Navy Department
Washington, D. C.

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A. EINSTEIN,
112, MERCER STREET,
PRINCETON,
NEW JERSEY, U.S.A.

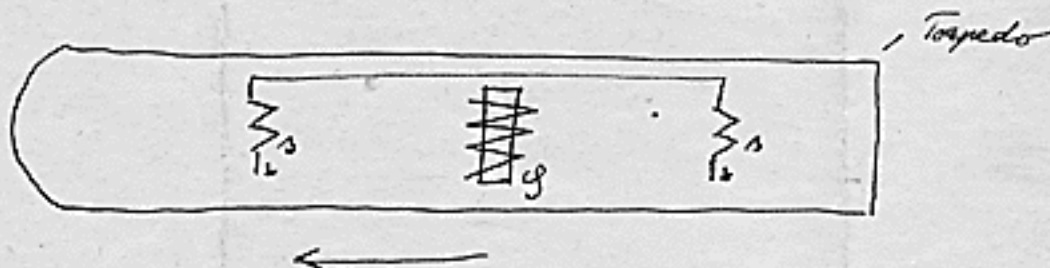
June 18, 1943

Lt. Stephen Brunauer
Bureau of Ordnance
Navy Dept.
Washington D.C.

Dear Mr. Brunauer:

I have already had two conversations with my colleagues Drs. White and Taub at the Institute. Both are very kind and helpful in discussing the problems with me and recommending me their special library.

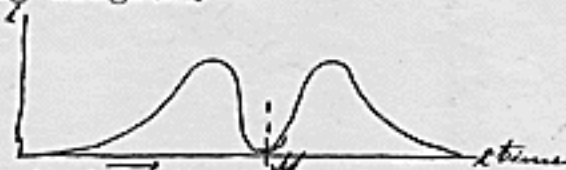
According to these discussions and a remark you made yourself when you were visiting me it seems to be desirable to have a device which automatically brings to explosion a torpedo passing below a ship at the right moment. I have an idea for an electro-magnetic device for this purpose which I would like to submit to you for your judgement. My colleagues here have no knowledge in this field and advised me to write to you.



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S is an electro-magnet producing an alternating magnetic field with vertical axis. s and s' are two coils with vertical axis connected in serie with opposite magnetic axis, which are located symmetrically to S. The current created by induction in those two coils may be multiplied by tubes (current i). The device is set in function only at a moment when the torpedo is far enough from the emitting ship to avoid the magnetic influence of the latter.

As long as the torpedo is on the way i will vanish for reasons of symmetry. The torpedo is supposed to travel deep enough so that it will not hit the target directly but pass below it. When the torpedo approaches the target there will be created through the nearby parts of the ship's hull an additional (induced) alternative magnetic field which at first will be stronger in s than in s' . There is now created a current i the intensity of which will change according to the following diagram:



M corresponds to the moment when the torpedo passes under the middle of the ship. At this moment i will again vanish for reasons of symmetry. This is the moment to put the explosion into action. It will be easy to construct an electrical contact device which functions if a current is first initiated and goes again to zero afterwards.

Pg.3, Lt.Brunauer, Navy Ordnance Bureau.

I realize that this idea is probably not new or that it might have been given up on account of technical difficulties. In that case I hope I have not taken up too much of your time.

Yours very sincerely,

A. Einstein

Professor Albert Einstein.

A. EINSTEIN,
112, MERCER STREET,
PRINCETON,
NEW JERSEY, U.S.A.

June 29, 1943

Lt. Stephen Brunauer
Bureau of Ordnance
Navy Department
Washington D.C.

Dear Mr. Brunauer:

I thank you for your kind letter of June 29th
and your offer to meet me on the station. On account of the
condition of my health, however, it is not advisable for me
to go to Washington without urgent necessity.

Very sincerely yours,

A. Einstein

A. EINSTEIN.
112, MERCER STREET,
PRINCETON,
NEW JERSEY, U.S.A.

July 30, 1943

Lt. Stephen Brunauer
Bureau of Ordnance
Navy Dept.
Washington D.C.

Dear Mr. Brunauer:

Thank you for your kind letter of July 28th. I have given some thought to the action of underwater-explosion to the armored hull of a ship and found a very rough mathematical simplification for the analysis of such process, a simplification which might be useful. I have shown it to my colleague Neumann who believed also that it might be practical. I am very glad that I shall have the opportunity to cooperate with him. He will tell you about it when he will see you.

I shall be glad to receive some empirical material. I shall not need much of it so that a visit to Washington for this purpose will not be necessary.

I thank you very heartily for your kind invitation which I shall gladly accept if the need arises. Without such need I shall try to avoid such trips knowing that I would be very much molested by snobbish people.

With best wishes

yours sincerely,

A. Einstein

A. EINSTEIN.
112, MERCER STREET,
PRINCETON,
NEW JERSEY, U.S.A.
August 13, 1943

Lt. Stephen Brunauer
Bureau of Ordnance
Navy Department
Washington D.C.

Dear Mr. Brunauer:

Enclosed I am sending you the signed
copies of the contract and my Naturalization Paper.

I am glad to hear that work is done con-
cerning the torpedo. I am very grateful that you have
send me my distinguished colleague Dr. Goranson who
showed me enough material to give me an adequate idea
of the process. I wrote him a suggestion about a possible
protection method for his competent judgement.

I have been asked by Dr. Vannevar Bush of the
Office of Scientific Research and Development to accept an
appointment as consultant to Division 8 of the National
Research Committee. I do not know whether this activity is
compatible with my Navy appointment and have written Dr. Bush
accordingly. I should be grateful for information to me or
Dr. Bush about this matter.

With best wishes, I am

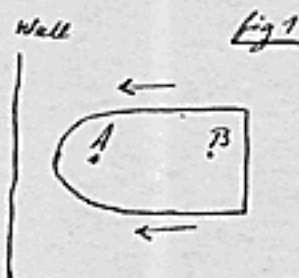
yours very sincerely,

A. Einstein

Professor Albert Einstein.

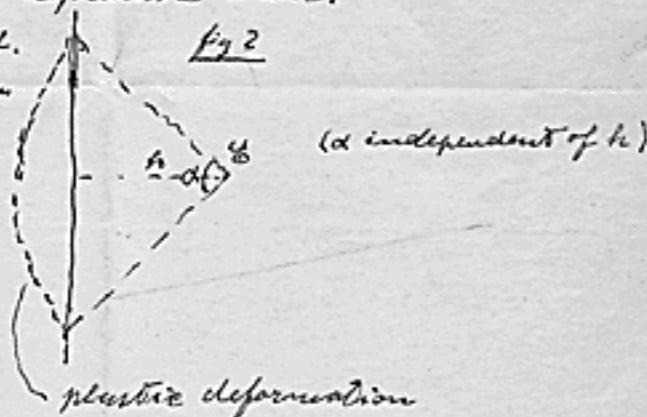
My dear Mr. Brummer!

According to the suggestion you expressed in your letter of 19. VIII I am giving you here reasons for my opinion concerning the best localisation for initiation of the Torpedo explosion, Dr. Neumann mentioned to you. The assertion is that the initiation should be made in front (Point A fig 1), not in the rear (point B, fig 1).



1. First a general remark of a more qualitative character concerning the action of a underwater explosion on a deformable wall.

If there is in C (Fig 2) an explosion the expl. pressure gives to a part of the wall (the extension of which being determined by a certain angle α and the distance h) certain velocities. Those velocities resp. the corresponding kinetic energy is mainly absorbed by a plastic deformation of the plate. If deformation is so deep enough the plate will break.



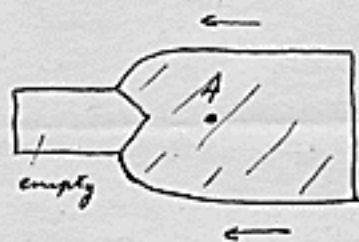
2. The extension of the deformed part of the plate is growing with h , the probability for the production of a hole is diminishing with growing h , the available energy being dispersed over a bigger volume of plate-material.

3. On pictures which were shown to me on your suggestion by Dr. Gorenson I have seen that the broken plates showed often radial lines of fractures (radial slots). This seems to show that the fracture is starting in the central region, extending afterwards radially in producing radial slots. One can also easily understand that maximum plastic deformation will occur in the central part (except in cases where there are weak spots due to the special structure of the wall).

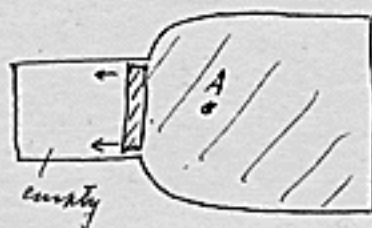
4. It seems therefore reasonable to bring about such a repetition of the explosion pressures (in time and space) that there be first a rather small central hole, which expands radially in the later phases of the explosion resp. deformation.

If ^{the explosion} this is initiated in B (Fig 1), the explosion pressures are reaching a considerable part of the wall nearly at the same time. The deformation will from the beginning extend over a considerable area. There will be no tendency to bring about the localized central hole mentioned before. If however the explosion is initiated in A, there will be in the first phase of the explosion a concentration of the biggest pressures on a relatively small area. There will be a probability for a perforation in a small area which will expand in the later phases of the deformation and radial slits will be produced.

5. According to these considerations it seems reasonable to provide ^(later) a special device in the front of the Torpedo to secure a perforation of the wall in the first phase of the explosion. This could be brought about through "cavity-effect"



or otherwise through impact of accelerated masses



I estimate that what I did told now for the Navy may be equivalent to 5 days work. It will be most convenient to send the corresponding money directly to the Institute for advanced study.

With kind wishes yours

A. Zimstein.

(Re2c)

ALBERT EINSTEIN
312, MERCER STREET
PRINCETON,
NEW JERSEY, U.S.A.

September 1st, 1943

Lieutenant Stephen Brunauer
Bureau of Ordnance
Navy Department
Washington D.C.

Dear Mr. Brunauer:

I am glad and happy that you and Mr. Von Neuman will visit me for a discussion of our problem.

I do not have the feeling that much can be achieved in this matter through mathematical calculation. The reason is the same as in many other cases: you have to introduce, for the sake of simplicity, many doubtful assumptions which may essentially influence the outcome. Experiment seems to me the only reliable way of confirmation in this case. Mr. Kirkwood, furthermore, is the most experienced man for such an enterprise. Till now I do not see a necessity to have an assistant.

I accept your proposition about the financial matters and shall arrange it with the Institute.

With best wishes,

sincerely yours,

A. Einstein

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A. EINSTEIN,
112, MERCER STREET,
PRINCETON,
NEW JERSEY, U.S.A.

January 4th, 1944

Commander Stephen Brunauer
Bureau of Ordnance
Navy Department
Washington D.C.

Dear Mr. Brunauer:

You have asked me yesterday to submit to you in writing my proposition to bring about a position of the torpedo parallel to the wall of the ship, before the explosion. In working this out, however, I became aware that the realization of this method is quite impossible. It is impossible, namely, to bring the torpedo to rest in working on it on such a short length which is available; the forces are so tremendous that they must mechanically destroy the torpedo.

If v is the speed of a torpedo of the mass m , the negative accelerating force K , the way of acceleration Δ , then K is given by the equation $\frac{1}{2} m v^2 = K \Delta$

If one puts f. instance $m = 100 \text{ kg.} = 10^5 \text{ g}$

$$v = \frac{25 \text{ m}}{\text{sek}} = 2,5 \cdot 10^3 \frac{\text{cm}}{\text{sek}}$$

$$\Delta = 10 \text{ cm}$$

one gets $K = 3 \cdot 10^{11}$ absolute units or 300 weight tons ($3 \cdot 10^5 \text{ kg.}$).

It is clear that the structure of the torpedo cannot stand this.

The torpedo has therefore to be brought to explosion before loosing its speed. In 0,001 second it makes a way of 2,5 cm. To be sure, the explosion should be finished before ~~essential parts~~ essential parts of the torpedo undergo deformation. It can f.i.

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PRINCETON,
NEW JERSEY, U.S.A.

Pg.2, Comdr. S.Brunauer, Bureau of Ordnance

be arranged that the head of the torpedo can undergo a deformation of appr. 10 cm, without the rest of the torpedo being mechanically deformed. This frontal part should contain empty space (or a space containing only air) to avoid that its deformation produces a compression wave propagating backwards with great speed. The torpedo-head would then look like this



The empty space has the only purpose to gain a few thousands of a second between the time of contact with the ship's wall in which the fuse-mechanism comes into function and the time in which the explosion is finished.

Probably care has been taken already of those circumstances in the construction of the torpedos now in use. I am telling it only because I have no information about it.

With kind regards,

sincerely yours,

A. Einstein.

Albert Einstein.

A. EINSTEIN,
112, MERCER STREET
PRINCETON,
NEW JERSEY, U.S.A.

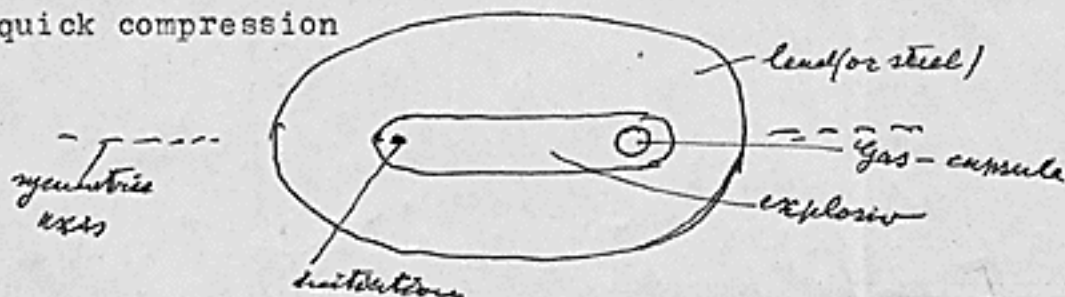
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October 15, 1944

Lt. Comm. Stephen Brunauer
Dr. G. Gamov
Bureau of Ordnance
Navy Department
Washington D.C.

Dear Mess. Brunauer and Gamov:

There is still another possibility to bring about
quick compression



The metal container, mainly through his inertia,
is nearly equivalent to a rigid wall. The location of initiation
and gas capsule is chosen in such a way that the compression
of the latter is effected in the shortest time.

Very sincerely yours,

A. Einstein.

Albert Einstein.